Benchmarking Public Sector Efficiency and Productivity Gains from Geographic Information Systems

A Case Study of Denver Smart Places at Stapleton Development Corporation

TR-109243

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REPORT SUMMARY

Geographic Information Systems (GIS) are becoming an integral part of the operations of public agencies whose tasks range from basic data management to complex decision support activities. Local governments and utilities have opportunities to collaborate on GIS projects in ways that save money and provide additional revenues to both entities.

Background

A recent EPRI-sponsored focus group with member utilities and city and county officials revealed a strong, mutual desire to collaborate more on solving mutual community problems with GIS technology. Utility companies often have a wealth of GIS experience and extensive GIS data repositories that have value for their customers and local public agencies. To assess opportunities in cultivating GIS projects, utilities need a better understanding of issues involved with implementing GIS with their customers.

Objectives

- To assess the impact of GIS on the operations of public agencies.
- To identify costs, benefits, and barriers to utility-customer projects that involve GIS technology.

Approach

As part of a public-private partnership, a GIS-based land use planning model, referred to as Smart Places, was developed and delivered to the Stapleton Development Corporation (SDC). In the first phase of their project, SDC used the model in planning redevelopment of the abandoned Stapleton Airport site in Denver. Analysts used on-site observations and a series of interviews to determine the model's impact on productivity and decision making. Using activity-based costing techniques, the second phase developed a methodology for evaluating GIS impact on organizations in general. The intent of this framework was to provide organizations with a mechanism for benchmarking their GIS uses. The project's final phase characterized GIS use by a number of public sector agencies.

Results

The Smart Places model was used only to a limited extent by SDC staff, even though model output was looked upon favorably by staff, public, and stakeholders. The main barrier to its widespread use was lack of a GIS champion to secure management and interagency support for GIS tools. GIS' primary benefit is its capability to enhance visualization and communication of site information to the public and potential parcel buyers and developers. Activity-based costing concepts also can be effectively applied to evaluation of GIS impacts on different types of organizations. This process-based approach identifies changes in activities with the introduction of GIS. The majority of survey respondents felt that GIS can change the way tasks are completed but that the technology had not yet been used to its full potential.

EPRI Perspective

The Smart Places model was developed as part of a Tailored Collaboration project with the Public Service of Colorado, City and County of Denver, Colorado Governor's Office of Energy Conservation, EPA Region VIII Office, and the Urban Consortium Energy Task Force. EPRI plans to take the Smart Places model to other communities to apply it to land use planning in partnership with EPRI members. A prototype of the Smart Places model is now available to members of the Community Economic Development Solutions Target. GIS is a technology that is still in its infancy; although EPRI believes its use can provide benefits, these benefits have yet to be measured.

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Interest Categories

Environmental compliance planning
Utility information systems
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Keywords

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ABSTRACT

Geographic information systems (GIS) are increasingly being applied by public agencies to assist in spatial data management and analysis. However, to date, very little has been done to estimate the ability of GIS to improve the efficiency and productivity of task completion and decision making. The goal of this project was twofold. First, the use of GIS in public agencies was studied to determine how the effect of GIS on their activities could be measured. Activity Based Costing was explored for this purpose. Then, using these results, the ability of GIS to improve public agency task completion was estimated for the case study example of Stapleton Development Corporation (SDC) in Denver, Colorado.

This project focused on public agencies in the State of Colorado. In particular, the potential use of the Denver Smart Places software by Stapleton Development Corporation was studied in depth. The primary research methods used were interviews and direct observation of agency activities relating to the use of GIS. This was carried out by three graduate students of Urban and Regional Planning at the University of Colorado at Denver, led by the Principal Investigator. Two sets of interviews were conducted within SDC. The first evaluated the employees' knowledge of GIS and its capabilities. The second explored the perceived potential of DSP within the organization. Simultaneously, interviews were conducted with a number of other public agencies within Colorado about their specific experiences with GIS. The final task was to compare these experiences with the use of DSP at SDC to estimate the ability of GIS to improve efficiency and productivity of task completion. In order to evaluate the impact of GIS, it was first necessary to develop a methodology for measuring its impact. This was done by exploring the literature on GIS effectiveness and on Activity Based Management.

The principal conclusions of this study are that: Activity Based Management can be effectively applied to the evaluation of GIS; a significant time lag is required before a complete assessment of the impact of GIS can be measured; users of GIS are generally satisfied that the tool is capable of improving agency task completion; and institutional barriers such as the lack of a GIS champion and lack of GIS use by consultants have a great effect on the ability of GIS to improve agency operations.

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CASE STUDY OF STAPLETON DEVELOPMENT CORPORATION

In March of 1997, Stapleton Development Corporation (SDC) acquired the hardware and software necessary to use geographic information systems, and the Denver Smart Places (DSP) software. DSP was designed specifically to assist in developing the former Stapleton Airport in Denver, Colorado in a sustainable manner. The software is a spatial decision support system built around a GIS interface in order to design, manage and analyze information relating to various land-use scenarios and their potential impacts on variables such as resource usage, job creation, transportation and infrastructure needs.

Smart Places Start-up and Maintenance Costs at SDC

The development of DSP was subsidized by financial support from a number of partner organizations including EPRI, Public Service Company of Colorado, Colorado Governor's Office of Energy Conservation, EPA Region VIII Office, the Urban Consortium Energy Task Force, and the City and County of Denver. As such, the costs outlined here represent only the costs incurred by SDC once the development was completed. Should other organizations' acquire DSP, their costs would include the additional cost of purchasing the Smart Places software.

Hardware:

Gateway Pentium 180 PC	$ 4,120.56
Network Card and Modem	$ 264.16
HP Color Plotter (DesignJet 750C)	$ 6,678.56
Extra memory for Plotter	$ 1,008.00
HP Adobe PostScript kit for Plotter	$ 1,046.40
Digitizer (Sumigraphics 17x24)	$ 1,868.90

Hardware (continued):	
Universal Power Supply (1400 watt)	$ 604.90
Upgrade to Network Hub	$ 104.00
Cabling	$ 39.70
Hardware subtotal	$15,735.18
Software:	
ESRI workbench	$ 337.00
ADE, Release 2	$ 664.40
AutoCAD	$ 2,844.30
Software subtotal	$ 3,847.70
Labor:	
Hardware Installation, 2 hours	$ 130.00
Software Installation, 18 hours	$ 360.00
Smart Places Training, 75 hours	$ 1,500.00
Applications Support, 280 hours	$ 5,600.00
Labor subtotal	$ 7,590.00
Total Start-up Cost	$27,172.88
Maintenance Costs:	
Hardware service contract for PCs	$40/month

Work at Stapleton Development Corporation without Smart Places

Stapleton Development Corporation (SDC) utilizes an accounting system that breaks down specific projects and activities within each department. Table 1-1 summarizes the activities for which GIS and/or DSP could be applied, as well as the costs incurred for those activities during the second quarter of 1997, before the application of DSP within the organization. Complete activity lists and cost information for all quarters is available directly from SDC. This data was supplied by SDC.

Table 1-1
Activity Costs without GIS

Unit	Activity	Cost Type	Cost, 2Q97
Executive	(1003) Plan and prepare the ISTBC physical space at Stapleton.	Labor	$ 2,189
Finance/ Administration	(2010) Develop property management information system and control procedures.	Labor	$ 4,094
Finance/ Administration	(2021) Continue to work on the completion of a blight study and the formation of a district eligible for tax increment financing at Stapleton to stimulate disposition.	Labor	$ 4,878
		Subcontract	$ 10,400
		Other	$ 10,864
Finance/ Administration	(2032) Develop a plan to procure grants to fund basic infrastructure improvements, such as access and utilities (including the upgrading of substandard utilities), that are generally necessary to make the property salable.	Labor	$ 1,585
Finance/ Administration	(2033) Prepare the first phase infrastructure financing plan for anticipated 1997-1999 basic infrastructure improvements, such as access and utilities that are generally necessary to make the property salable.	Labor	$ 6,574
		Other	$ 1,252
Open Space/ Environment	(3031) Initiate preparation of specific plans for designating and remediating open space areas within the Property, which will enhance disposition.	Labor	$ 727
		Other	$ 791
Open Space/ Environment	(3033) Commence preparation of a management plan for parks, recreation, and open space area initiatives in a manner contemplated by the Development Plan.	Labor	$ 1,482
		Other	$ 5

Open Space/ Environment	(3041) Provide design guideline input with respect to vegetation for Sand Creek and Westerly Creek regional greenways and other parks and open spaces.	Labor	$ 6,224
		Other	$ 1,706
Legal	(4001) Develop comprehensive understanding of all legal considerations, such as easements, encumbrances, etc.	Labor	$ 60,985
		Subcontract	$ 27,384
		Other	$108,878
Marketing	(5001) Manage media relations by producing releases, media briefs, news opportunities, etc.	Labor	$ 5,831
		Other	$ 11,076
Marketing	(5004) Coordinate marketing program with long-term disposition plan.	Labor	$ 10,328
		Other	$ 1,938
Marketing	(5010) Develop site image and identity to provide for disposition of Property.	Labor	$ 6,872
		Subcontract	$ 6,842
		Other	$ 2,384
Community Relations	(6003) Build community support for zoning change applications and disposition activity.	Labor	$ 16,539
		Other	$ 1,827
Community Relations	(6004) Organize local Stapleton businesses to facilitate and support zoning changes that are necessary for disposition of Property.	Labor	$ 6,405
Planning and Development	(7001) Project management services for ongoing projects.	Labor	$ 8,874
		Other	$ 2,068
Planning and Development	(7002) Provide oversight and recommendations for construction and engineering activities.	Labor	$ 2,132
		Other	$ 158
Planning and Development	(7004) Provide design oversight that otherwise would be provided by the City for Stapleton tenants and Property owners in order to ensure Development Plan objectives and maximize the value realized during the disposition process.	Labor	$ 2,132
		Other	$ 1,651
Planning and Development	(7011) Complete residential area District Plan	Labor	$ 19,861
		Subcontract	$169,975
		Other	$100,293

Planning and Development	(7020) Framework Zoning	Labor	$ 9,003
		Subcontract	$ 21,751
		Other	$ 18,532
Planning and Development	(7040) Continue I-70 Corridor design work to enhance disposition and preserve value of the Property.	Labor	$ 5,146
		Other	$ 18,051
Planning and Development	(7091) Asbestos Survey of SIA buildings	Labor	$ 5,799
		Other	$ 360
Asset Management	(8011) Develop effective leasing criteria, evaluate all listings, maximize lease income, and initiate new leases for Stapleton.	Labor	$ 20,336
		Other	$ 2,025
Asset Management	(8031) Develop detailed building analysis and inventory of the terminal complex to facilitate evaluation of revenue generation through reuse.	Labor	$ 18,436
		Other	$ 12,968

Potential of Smart Places at Stapleton Development Corporation

At this time it is not possible to provide cost and benefit estimates for tasks done with GIS at Stapleton Development Corporation because the organizations staff has not applied the system to their activities. The DSP system has been used by interns to create map outputs for political and community presentations. As such, a small amount of money has been saved by producing these outputs in-house rather than having to send them to a graphics production company. It is not possible to quantify the exact amount of savings because of incorrect account postings. The savings are estimated to be less than $500.

Instead, this section will discuss the potential efficiencies for tasks done with GIS/DSP at SDC and will discuss the institutional barriers that have stood in the way of its implementation thus far.

Baseline Survey

At the beginning of this project, a baseline survey was conducted to determine what types of activities were done by each department within SDC, and how mapping and spatial analysis were used, or could be used. These interviews were conducted after information presentations about DSP were made to the staff. Thus, although only one

individual within SDC had any type of education about GIS, all staff members were aware of the existence of DSP and GIS, and had a brief introduction to their purpose at SDC.

From these surveys it was found that DSP could be helpful to a number of individual departments. The previous section outlined specific SDC defined tasks for which the research team felt DSP could be used. This section will outline this potential in more detail and will discuss the potential costs and benefits associated with its application.

Executive - International Sustainable Technology Business Center (ISTBC)

The major function of this department is to develop business opportunities at the site that are economical and environmentally sustainable. This includes efforts to integrate recycling and other environmental businesses into economic development activities at the site. Maps are not used regularly for activities of this site, so the short term potential for DSP and GIS by this group is limited. However, over the long term, DSP could be used to analyze the potential resource generation and consumption activities at the site. This could then be linked to sustainable technology businesses at the site. For example, if a recycling business were to locate on the site, DSP could estimate the amount of materials that could be generated to provide input for the business. In this case the Radix evaluation models of the system would be of more use than the GIS component of DSP, the Scenario Builder.

The benefit of DSP would be improved access to data and analysis capabilities that could be used to develop marketing plans for attracting sustainable businesses. The cost would be the time required by staff to determine how DSP could supply information that would assist them. There may also be additional costs associated with gathering and developing additional data to support desired analyses.

Finance & Accounting

The major function of this department is to manage the budget of SDC. Part of this effort involves identifying new sources of funding for SDC projects. Maps are not used extensively by this group, but there are a couple of opportunities for using DSP as an information management and cost-tracking tool. First, expenses for the site are tracked by land parcel and district. As such, a parcel database could be modified to include a breakdown of expenses for the site. Thematic maps could then be made to demonstrate this breakdown of expenditures spatially. If similar maps were created for parcel values, spatial comparisons could be done to see if expenses and values were related spatially. This could assist in developing budgets for future land-use development or remediation projects.

Another activity for which DSP has potential within this department is the development of a property management information system. To do this a new GIS coverage would need to be created. This GIS database should include the attribute fields needed for accounting and administrative purposes, and should be spatially compatible with other coverages within DSP. This database should be updated regularly to include additions, deletions and changes to specific properties on the site. The system could then be used to track property costs and revenues generated per building or parcel.

DSP could also assist in the Blight Study being done by this unit. Again, the appropriate database would need to be created first. Then, the spatial distribution of property assets and detriments could be studied to identify the area(s) that would be most appropriate for the formation of a district eligible for tax increment financing. It would also facilitate the comparison of district formation with the original plans for the site as developed by the Stapleton Redevelopment Foundation. In addition to using DSP to assist in site selection, it could also be used to analyze the spatial relations between this district and others on the site.

The third task for which DSP could be helpful is in strategically identifying areas within the site that could be assisted by grant procurement. For example, if a database of existing infrastructure and desired infrastructure were developed, this could be used with the original site plan or future site designs to demonstrate to funding agencies how and why funding is necessary to meet the goals of the redevelopment effort.

The cost associated with these applications is the time of the staff and of a GIS analyst to customize the data. The benefit would be improved efficiency in accessing information and the ability to communicate ideas graphically. If DSP were to assist in obtaining grants, a portion of the value of those grants would be a measurable financial value of the system.

Open Space and Environment

This is perhaps one of the most appropriate departments for implementing DSP/GIS because its main activities are so closely tied to land use and spatial data. The major functions of this unit include planning and managing park projects, including ecological surveys, fund raising and providing information to relevant parties. To assist in open space preservation and the protection of ecologically sensitive areas, GIS is a valuable tool for data management and analysis. In addition, the Scenario Builder and the Radix evaluation models can be used to design and evaluate open space plans. As landuse plans are finalized, DSP can be used to develop management plans for parks and recreation within the site, and to study potential linkages between the site and parks in neighboring jurisdictions. A significant amount of the data needed by this

department is already available in DSP. Some refinements would be necessary to maintain the data as additional designs are generated and development occurs.

As with the Finance and Accounting Department, this department can use DSP to demonstrate goals and needs to potential grant providers. The Scenario Builder can be used to design Open Space and Environmental Protection design scenarios, and the Radix Evaluation models can be run to estimate the potential value of the project in terms of resource preservation. These potential applications could be realized in the short term. The cost of GIS use by this department thus far has been the need to allocate time to work with the system and develop the data. Again, if this department was to use DSP to develop analyses and outputs for funding proposals, a portion of any funding received could be a quantifiable measure of the value of the system.

Legal

The potential use of DSP by SDC's legal counsel is as an information management and communication tool. Legal documents associated with specific parcels such as site surveys, easements and environmental studies can be scanned into the system and linked to a parcel database for quick reference. It would also be possible to secure the system so that a password is required before sensitive documents could be accessed.

One expense of this type of application would be the cost of purchasing scanning hardware and software, which can be obtained for as little as $300. More significant would be the cost of staff time to scan documents and link them to the appropriate GIS database. The primary benefits would be the improved efficiency in information retrieval. Assuming it takes five minutes to retrieve a paper document relating to the site and one minute to find the same document by pointing and clicking on the computer system, four minutes could be saved per document query. If the time for legal support is valued at $100 per hour, this would result in a savings of six to seven dollars per query. This could add up to significant cost savings with heavy query demands.

Marketing

This group is charged with selling the land to users and buyers, as well as providing information about SDC's activities to the media and constituent groups. Maps are used to present site plans, to demonstrate access to the site, and to identify specific locations. The Scenario Builder component of DSP is the most useful to this department for managing information and brainstorming alternatives with potential clients. Output from DSP could be used in media releases, a web site for SDC, a CD-ROM of site maps and characteristics, and other marketing products. Internally, DSP could be used to assist in coordinating the marketing program with long-term disposition plans, and to assist in developing a site image and marketable identity.

The costs of application for this department would take the form of staff time to develop the system and data needs. The benefits would depend on how the outputs are used in attracting developers and buyers. It could also improve access to information about disposition plans and progress if a database were maintained for this purpose.

Community Relations

The major task of this department is to relate to community groups, the media and government agencies. DSP can be a useful tool for developing presentations to these stakeholders. By entering proposed design scenarios into the Scenario Builder and running evaluation models to estimate the impact of the plans, visual tools such as maps, tables and charts can be created with DSP to demonstrate relevant information to constituents. In addition, with small groups, DSP can be used interactively by stakeholders to modify design scenarios, or develop plans of their own. For example, negotiations with Denver Public Schools on the location of future school sites could be assisted by the use of the Scenario Builder in DSP. Another activity for which DSP could be helpful is in organizing local businesses to facilitate and support the zoning changes that are necessary for the disposition of the property. Using the Scenario Builder, zoning can be designed and its implications demonstrated in relation to other scenario designs such as the original plan developed by the former Stapleton Redevelopment Foundation.

The only cost associated with this application is the time for staff to understand how to use the system. DSP's potential benefits to this department have been demonstrated on a limited scale already. Outputs from the Scenario Builder have been created and used in meetings with stakeholders. Constituents were impressed by the professional quality and clarity of DSP's output, and by the implication that sophisticated computer analyses were done by SDC. This perceived benefit is important to an organization under as much political scrutiny as SDC.

Planning and Development

Along with the Open Space and Environment Department, Planning and Development is a prime candidate for the application of DSP, and the only other department in SDC that has applied DSP or GIS thus far. The primary task of this group is to design and plan the redevelopment of the site and to provide expertise to community and development companies. This group uses and produces maps more than any other within the organization. In addition, they provide a great deal of support in developing and outputting designs for other departments within SDC.

The only realized benefit of DSP for this unit thus far, as noted under Community Relations, is the perception of SDC's work by constituents. However, there are many

other potential benefits that can be realized. First, DSP can be used to link the activities of all of the units because they all have to work with physical designs for the site. DSP can facilitate communication of ideas internally, as well as document ideas, evaluation results and decisions. DSP can also be used to manage and document the many design iterations produced by consultants for land use, district planning, infrastructure development, and service delivery. Currently, each consultant maintains their own set of paper and/or CAD maps and site plans. By entering these designs into DSP, multiple issues can be considered simultaneously leading to more efficient and unified analyses.

In terms of cost savings, some of the editing of designs and landuse plans could be done in-house with DSP/GIS rather than by consultants, thus providing savings in fees charged by subcontractors. Outside fees could also be reduced by more efficient information sharing that would be possible if DSP were used to manage and communicate the designs of subcontractors. The biggest financial cost associated with the use of DSP by Planning and Design is the cost of time and training for the staff in this group. In addition, there is an institutional cost associated with shifting part of the design process to computers, and GIS in particular, rather than traditional hand drawn designs and computer aided design (CAD) programs. The use of DSP also requires a shift in thinking to incorporate sustainable development analyses directly into design development. With DSP it is possible to evaluate the resource consumption and transportation requirements associated with particular lot designs. This is not traditionally done by design professionals and requires a dramatic change in their thinking and practice.

Asset Management

This department is charged with managing the existing site. This involves maintaining buildings and land, and leasing property to generate revenues. Maps are used by this group to study utilities and access. In responding to inquiries by people who are interested in leasing property or planning events at Stapleton, a number of documents are used. This includes photos, data about building specifications, blue prints and legal documents. Currently, staff must work from memory, or refer to paper files in order to provide information. The efficiency and timeliness of response could be improved by scanning documents into DSP and attaching them to building and parcel files. In that way, it would only be necessary to point and click to a specific location on the site to access the relevant information. There would be some cost savings in terms of staff time searching for documents. An additional benefit would be the improved perception of the organization by those who make inquiries. The cost of use for this department would include the time to input the relevant documents and data, and the cost of hardware and software to run DSP. At this time DSP is only accessible from one computer station located in SDC's downtown office. There is no access to DSP at the

site where Asset Management is located. The cost of hardware and software for starting up DSP in SDC's downtown office was approximately $19,700.

Summary of Potential Costs and Benefits

The full benefits of the use of DSP can only be realized over time. It is expected that the most significant benefits will result from efficiencies in information sharing. Using a common platform for managing and developing spatial information can improve communications within SDC, between SDC and consultants, between consultants of SDC, and between SDC and community groups. The quantifiable result of this will be lower fees paid to subcontractors, and more efficient use of staff time. A qualitative benefit of DSP has been, and will continue to be the perception of SDC's work by constituents. The use of computers for analysis makes SDC appear to be doing cutting edge work. In fact, the public is beginning to have greater expectations of the technological capabilities of government agencies. The time is approaching where respect for an agency will be diminished if they do not have the technological capabilities that its stakeholders know are possible.

For each of these departments, the potential use for DSP will have costs associated with it. The largest cost will be for a staff person with the technical capabilities to develop the necessary data sets, and to manage the system. The market value for a full time individual with these skills will be between $35,000 and $45,000 a year plus benefits. It may be possible to hire a person half time to do this work depending on the number of projects desired. Another staffing option is the use of interns from local universities on a project by project basis. The drawback of this option is the lack of continuity between projects, and the potential lack of commitment to the goals of SDC. This solution would also make the use of DSP appear unimportant and could diminish its success because of the lack of an internal supporter.

In order to realize the full benefits of a tool such as DSP, it will need to be easily accessible to all staff members, consultants and constituents. This would be most effectively done through a local area network (LAN). The computer currently running DSP could be converted to a server, and would store the data files and DSP software. It may be necessary to upgrade this machine with additional RAM and hard-drive storage as data sets are developed and use of the system increases. The cost of this upgrade is likely to cost under $1,000 at current market prices. Once a LAN is in place, all staff would need a copy of ArcView 3.0 in order to run DSP. It may also be necessary to upgrade the computers of some staff members for optimal performance. Finally, an individual would be needed to ensure that the network runs smoothly. This could be the same individual that manages the DSP/GIS system.

Benchmarking Costs and Benefits of GIS/DSP Use

It is possible to determine the quantitative and qualitative costs and benefits of the use of GIS and DSP using the measures presented above, or an activity based approach. Since SDC has not begun to use these tools to do their work, it is not possible to present results for SDC at this time. However, a methodology for measuring the impact of GIS is presented in Chapter 2. Tables 1-2 through 1-5 present lists of quantitative and qualitative costs and benefits that could be expected from SDC's use of GIS/DSP along with potential measures of performance.

Table 1-2
Quantitative Benefits of GIS/DSP Use

Type of Benefit	Measures
Reduced consultant time	Consultant fees
	Hours billed per quarter
Improved communications	Length of meetings and public hearings
	Average number of tasks completed in a one-hour meeting.
	Reduced errors/rework caused by miscommunication of ideas/plans.
Materials consumption	Cost of materials per activity
Improved coordination	Number of alterations necessary to correct design plans for accuracy and compatibility.
	Amount of time necessary to correct design plans for accuracy and compatibility.
Time savings for activity and task completion.	Amount of time to complete activity or task.
	Amount of time saved in responding to inquiries.
Improved planning, design and development results.	Number of attributes considered in a single design and planning scenario (such as resource use, transportation needs, etc.).

Table 1-3
Qualitative Benefits of GIS/DSP Use

Type of Benefit	Measures
Perceived quality of SDC's work.	Public satisfaction.
	Regional/national recognition
	Acceptance of SDC's recommendations.
Improved communications	Media coverage of SDC.

	Public faith in SDC's work.
	Reduction in political friction.
Improved planning, design and development results.	Acceptance of SDC's recommendations.
	Stakeholder satisfaction with results.

Table 1-4
Quantitative Costs of GIS/DSP Use

Type of Cost	Measures
Hardware	Cost of workstations, plotters and peripherals
	Maintenance costs (monthly)
Software	License fees
	Software upgrades and maintenance costs
	Software training fees
	Time for software training classes per staff member
Staff	Cost for paying an individual to maintain system and to update and develop data sets as necessary.
	Time for staff to become proficient using system.
Space	Space needed for hardware and staff to run GIS/DSP (square feet).

Table 1-5
Qualitative Costs of GIS/DSP Use

Type of Cost	Measure
Distrust of results	Lack of use of system
Over reliance on computer output	Inadequate scrutiny of results
	Reduced creativity in scenario design

Institutional Barriers

As referred to earlier in this chapter, DSP and GIS have not been widely applied thus far at SDC. There are five reasons for this: the lack of a GIS champion; limited of staff time available for using DSP/GIS; SDC/City political complications; consultants not using GIS; and a general uneasiness with the role of computers by the professions represented at SDC.

A successful GIS project needs an individual or group of individuals who whole-heartedly support and promote the use of GIS within the organization. From the initial staff surveys done for this research project it was apparent that there was general acceptance of the idea of using GIS and DSP, but not a clear understanding of how that would happen, and how it would effect each individual's work. In other words, nobody within the organization has a great enough understanding of GIS and DSP, nor is anyone interested enough to dedicate themselves to its successful implementation.

The lack of a champion is related to the second barrier, lack of staff time to use DSP. Although some staff recognize its potential, the requirements of their day to day job do not afford them the time, and political risk, of becoming the champion. That is, there is a significant cost without a clear reward for being the GIS champion since its benefits to SDC are unclear. The time required to learn to use GIS and DSP is dependent on the staff member's computer background. Given the relatively high level of education of SDC's staff, it is believed that people could be trained quickly if the time was available. However, none of the current SDC staff have GIS use as part of their job description. As with many public agencies, daily "firedrills" and demands take precedence over learning new software. In addition, once training is completed, staff must have time to apply the software. This requires more time to familiarize themselves with appropriate applications before it becomes a regular part of the way they do their work.

The third barrier relates to the political atmosphere surrounding SDC. As an organization they are charged with redeveloping the site in order to provide revenue to the City and County of Denver. Maximizing revenues is a stated priority. While a stated goal of SDC is to develop the area in a manner that provides significant revenues to the City, and at the same time adopting principles of sustainable development, this belief is not held in the same regard by some stakeholders in the development community. To them, DSP is considered a secondary consideration within the organization rather than as a tool to help them meet all of their goals simultaneously.

The fourth barrier is the lack of use of GIS and sustainable development models by SDC's team of consultants. A significant amount of the design and planning work done for the site is subcontracted out to consultants. These subcontractors have not themselves begun to use GIS regularly in their work. In addition, if they were required to use GIS or DSP, they may charge higher rates for their work because of a perceived increase in effort required. Therefore, when a design is generated for a sub-area of the

site, it is not done as part of a GIS application. If it is done digitally at all it is done using Computer Aided Design (CAD) software; however, then someone at SDC would need to convert the file to make it compatible with DSP. Due to the lack of GIS experience of staff, however, this is not currently possible.

The final barrier has to do with the general acceptance of computers by designers, planners and developers. Although most recognize their value and importance, they were usually not a part of their formal professional training or practice. Therefore it requires a significant shift in thinking to integrate a tool such as GIS and SDC into everyday work activities. In some cases, there is a general distrust of computers for design work and planning. This is based in the fear that human creativity and compassion will be eliminated from design and planning processes. As new professionals are trained with GIS and progress through the professions, this attitude is likely to change. Time and education will eventually overcome this barrier.

2

THE USE OF ACTIVITY BASED COSTING FOR BENCHMARKING THE USE OF GIS

Introduction

It is widely believed by public officials that geographic information systems (GIS) and other types of computer systems provide a net benefit to an organization. (Budic, 1994, Kraemer and Danziger, 1993, Norris and Kraemer, 1996). However, there is some uncertainty regarding the benefits of GIS and whether they are greater than the costs. This is compounded by the fact that once such a system is obtained, technical and organizational issues can inhibit GIS from becoming a mainstream planning tool (Campbell and Masser, 1995, Ventura, 1995). To better understand the value of GIS, a systematic methodology is needed to identify real, rather than perceived, impacts of its use. These quantitative and qualitative impacts can then be compared with the goals of the organization to assess the role of GIS and prescribe changes that will increase its effectiveness.

This chapter presents such a methodology for analyzing the use of GIS by public organizations. It focuses on work processes, as done by Mooney, Gurbaxani and Kraemer (1995), and integrates some methods of activity based management (ABM) from the private sector. Using a descriptive, process-oriented approach, organizations can identify how GIS changes the way activities are done. The results of the descriptive research can then be used in a prescriptive manner to determine where GIS may have the most potential to enhance work processes, as well as to identify barriers to effective implementation.

Purpose

Computers are becoming an integral part of public agencies' activities from basic data management to more complex decision support activities. In fact, many managers believe that computer based information is instrumental to their job (Kraemer et al, 1993). Geographic Information Systems (GIS) represent one category of computer technology that has shown a great deal of promise. However, a variety of questions about GIS exist. Is the cost of GIS worth the expenditure? Is GIS effective in

organizations? What inhibits full implementation and use of GIS? What is the value of GIS to an organization?

These same questions have been explored for over two decades with regards to computers and information technology in general. (Kraemer and King, 1977, Danziger and Kraemer, 1986, Innes and Simpson, 1993, Coyne et al, 1996). Research on the public sector has shown that public officials believe GIS and other types of computer systems provide a net benefit to an agency (Budic 1994, Kraemer, Danziger, Dunkle and King 1993, and Norris 1989). And, an organization's ability to deal with change has been identified as an influential factor in the effectiveness of GIS (Campbell and Masser 1995, Campbell 1996). At the firm and industry level work has been done to evaluate the benefits of information technology (IT) in the private sector, and a process oriented framework for assessing the business value of IT has been suggested (Mooney, et al, 1996). However, little has been done to identify the impact of IT, and GIS in particular, on the processes and activities of public sector organizations.

The purpose of this chapter is to present a process oriented methodology for understanding the impact of GIS on a public agency. For decades, researchers and practitioners alike have sought to measure the value of computers and to measure their costs and benefits. However, benefits, costs and value are highly subjective concepts. This makes comparisons within and between organizations difficult if not impossible. In addition, a cost-benefit approach leaves out factors that are not quantifiable, such as organizational effects. Rather than attempting to calculate the value or benefit of a computer system such as GIS, it is more informative to identify its qualitative and quantitative impacts on an organization and its processes. This provides a foundation upon which assessments and suggestions can be built.

The methodology presented has two general purposes. First, by initially focusing on an organization's processes before GIS is implemented, applications that are appropriate and have a high probability of successful GIS implementation can be identified. Second, by studying these processes over time as GIS use evolves, changes will be identified. Impacts can then be compared to expectations and goals to provide a less arbitrary, and more comprehensive basis for evaluation. This can then be used by an organization to guide the use of GIS internally. Then, over time, information about process changes can be compared across a field or area of application to determine if there are commonalties or influential variables. This may then facilitate the development of measures of performance.

A Process Based Approach

Campbell and Masser (1995) have discussed the importance and implications of change brought on an organization due to the adoption of GIS. And, they have identified an organization's ability to deal with change as a determining factor in the successful

implementation of GIS. Thus, a study of these changes seems prudent. The question is then, how can these changes be identified and understood. If GIS is viewed as a tool, rather than the ultimate goal, than it is best to observe how this tool effects practice. An approach that focuses on the processes of an organization, and how GIS fits into these, should then seem reasonable. Such an approach will track changes in organizational processes as GIS use evolves, and should account for both quantifiable and qualitative changes.

The approach presented here uses an activity or process-oriented approach. This has been suggested in the business literature by Mooney, Gurbaxani and Kraemer (1996) as appropriate for understanding the relationship between information technology (IT) and an organization. They state that a research strategy that focuses on processes will facilitate the identification of facets of IT that add value to an organization, and that this is needed to develop measures of IT value. With such an approach, qualitative and social impacts are identified more systematically. This is desirable given research findings on the influence of political and social factors on GIS implementation (Campbell, 1996, Campbell and Masser, 1995).

The framework developed by Mooney, Gurbaxani and Kraemer (1996) to assess the business value of information technology begins with the development of a typology of processes. A process is defined as a set of activities or tasks performed over time with defined inputs and outputs. Their typology distinguishes between operational (task oriented) and managerial (decision oriented) processes, and itemizes specific activities within each type. Once the processes of an organization are understood, the next stage is to identify and categorize the potential impacts of IT on those processes. This includes changes in efficiency and reliability, informational and communications effects, as well as the identification of opportunities for process re-engineering. The final stage is an analysis of the value of IT stemming from the impacts on the identified processes. The purpose is to find measures of value that can facilitate the comparison of impacts with the goals of the organization for which IT was employed. The intent of this work, however, is not a methodology for valuation of IT. Rather, it is to establish a framework to "specify the object of measurement more precisely." (Mooney et al, 1996, pg. 76).

The spirit of the methodology presented below is also focused on identifying the object of measurement, in this case impacts or changes due to GIS. Rather than a framework for assessing value, however, the purpose is to provide a methodology that helps suggest potential applications for GIS, and that then identifies the changes or impacts from its use over time. This identification may be a complex undertaking and a systematic, repeatable set of procedures is needed if results are to be useful in assessing value at some point.

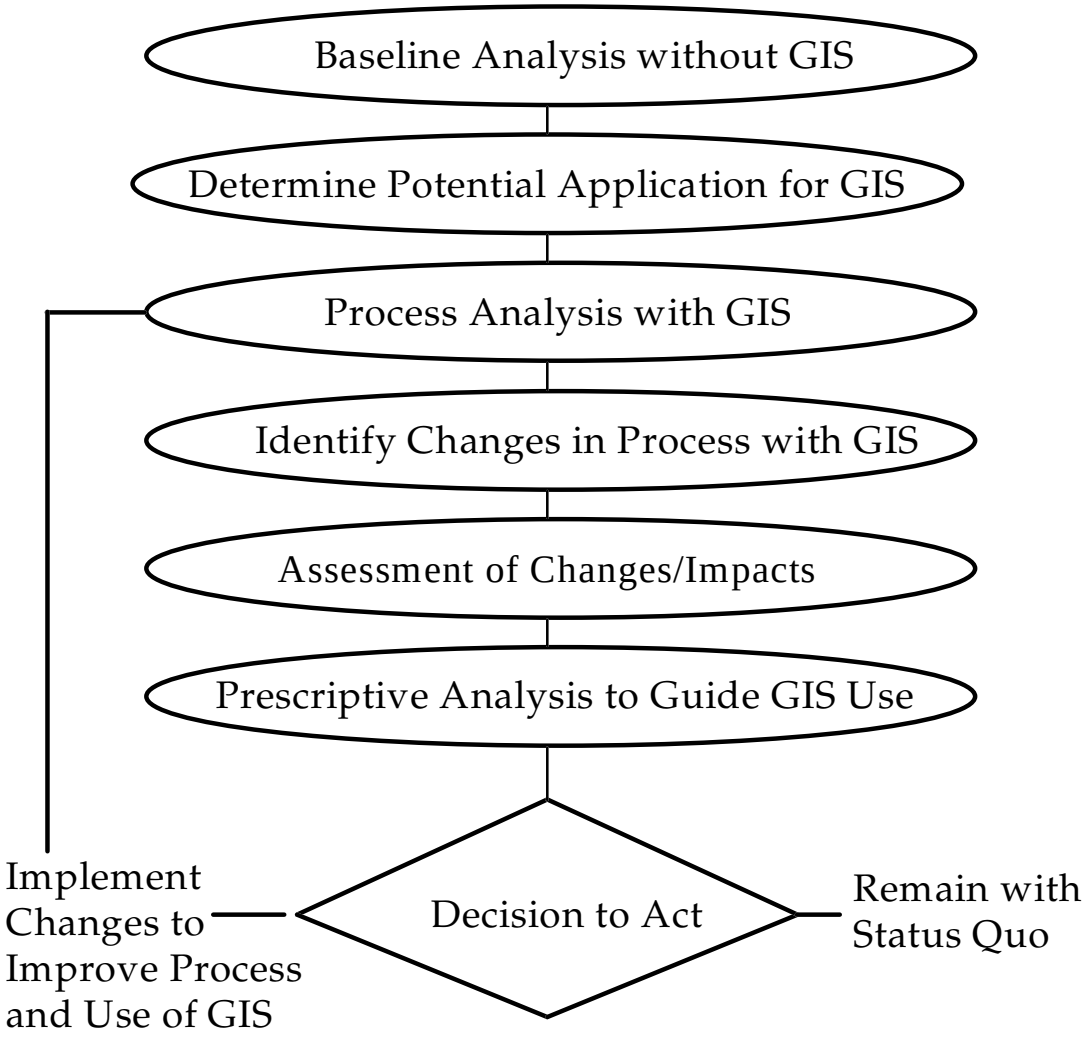

Figure 2-1
Benchmarking Methodology

A Methodology for Benchmarking the Impact of GIS

A methodology for identifying the impact of GIS in public sector agencies should consist of descriptive, normative and prescriptive phases. These can then facilitate the understanding, assessment and improvement of GIS use. Figure I outlines the phases of the methodology. Phases I is descriptive. It is here that details about processes with and without GIS are identified. The next phase is prescriptive. Using the information about organizational processes, areas where the application of GIS would be most appropriate are determined. Once GIS is applied, another descriptive evaluation is done in Phase III. Phase IV is the final descriptive phase. It is here that the process outlines from Phases III and I are compared to identify where changes and impacts have occurred with the application of GIS. In Phase V an assessment of these impacts is made. This phase is subjective and depends on the perspective and goals of the organization. It requires that a normative statement about the organization exists in order to compare the changes to the desired state. From this phase an organization can determine whether or not GIS is effective, even if it is not possible to place a single value on its use. Phase VI is prescriptive. Since GIS use evolves over time, the results of the prior phases can be used to guide the future use of GIS. If organizational changes are made, the methodology can be applied again from Phase III onward to evaluate the effectiveness of the changes.

Phase I - Process Analysis Before GIS

The starting point is a descriptive analysis of the processes of an organization before GIS is acquired. For each work process identified, details about the activities that comprise the process should be specified. This includes identifying the individuals performing each activity, resource inputs and outputs, the tools used to perform each activity, the steps taken to complete an activity, and the flow of activities that produce each specific output. Links and points of contact between activities, individuals, inputs and outputs should be identified. From this, a process and activity flow diagram for an organization is developed.

Field research and methods from the private sector are employed to guide this analysis of processes. Activity Based Management (ABM) is an accounting method that focuses on work activities rather than organizational units. Although it is used primarily for financial analysis, it provides useful guidelines for identifying activities (Cooper et al, 1992, Brimson, 1991).

As with most research projects, the first step is to determine the scope of the analysis. In this case the focus is on processes, which are broadly defined. They consist of a set of activities that may be accomplished in a specific order or simultaneously. These activities are completed by performing a series of specific tasks. For example, planning

the future use of an area of land is a process that includes activities such as reviewing requirements, analyzing local conditions and communicating with stakeholders. Tasks are the specific steps taken to complete these activities such as reading documents, creating maps, writing letters and holding meetings. Depending on the level of detail desired, analysis can take place at the activity or task level. With a predetermined focus on the use of GIS, the scope should encompass all activities or tasks that may be related to this tool.

Next, a technique for identifying activities or tasks must be chosen. Brimson (1991) suggests developing a worksheet that identifies each activity, its duration, inputs and outputs. To identify these activities he discusses six techniques: the analysis of historical records, the analysis of organizational units, the analysis of business processes, the analysis of business functions, a directed engineering study, and reconciliation of activity definitions. The choice of technique will depend on the organization. Many public agencies do not keep detailed accounts of their daily activities, and many do not have formal flowcharts of activities. Therefore, the technique employed in the methodology for public agencies is an analysis by organizational unit. This lends itself to field research and is more conducive to the consideration of social issues than a business function or engineering analysis.

Collecting data about processes involves the use of existing documentation, surveys, interviews and first hand observations to develop the sets of activities performed by an organization. This should be done by an unbiased outside observer or participant observer so members of the organization do not feel threatened or pressured to answer or act in a particular manner. Depending on the level of detail desired, the initial identification of activities or tasks may require hours, days or weeks of observation and questioning. For this reason, the successful completion of these activities is dependent upon the organization's willingness to participate in the study.

To identify the agency's activities a multi-tiered approach is suggested. This is presented below in Figure II. The approach suggested is not a linear one. First, the organizational chart and other types of documentation are used to understand how the work is divided. The document review process should be undertaken early, and should be supplemented with informal conversations and observations of the agency. The information gained is used to structure and design surveys and interviews. Surveys are administered to gauge employee knowledge of and attitudes toward technology and their jobs. Results will help establish a baseline understanding of the organization. However, unless employees are required to keep logs of their time, surveying is inadequate for understanding an agency. To supplement this, observations of staff at meetings and presentations should be made to develop an understanding of personal and organizational relationships.

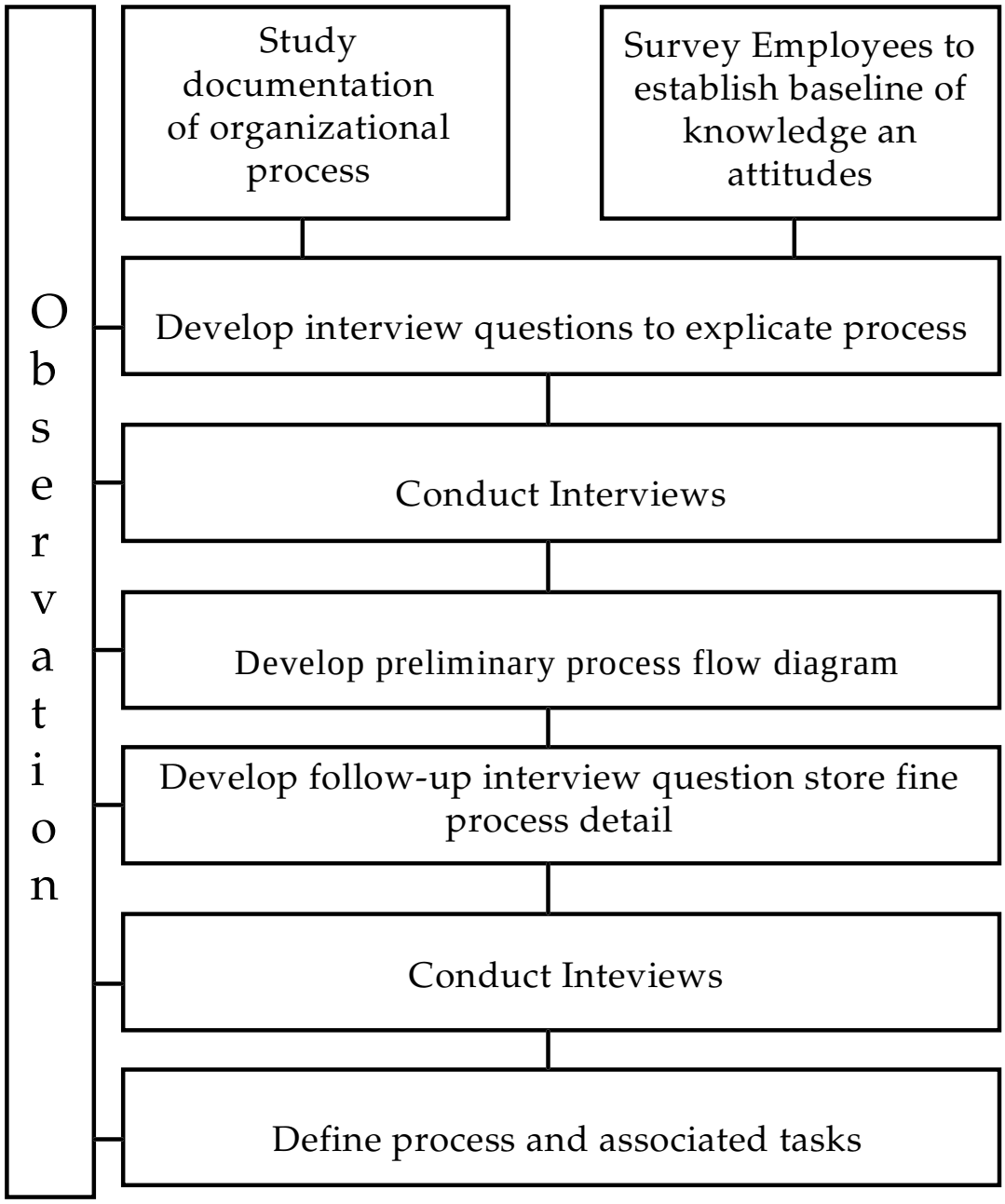

Figure 2-2
Process Analysis

As a baseline understanding of an organization is achieved, a series of structured interviews are conducted. For small agencies it will be possible to interview all employees. In large organizations, however, it will be necessary to identify key individuals, such as managers and selected staff, who can provide insight into the processes and activities performed. The first interviews should be designed to identify general information about what an individual does and the inputs and outputs involved. Inputs and outputs should be defined broadly to include physical objects such as maps and reports, as well as less tangible, but equally important items such as presentations at meetings, decisions, and communications. If there are interactions with other individuals and processes they can also be explored in these interviews.

While interviews and surveys can provide valuable insight into organizational processes, it is helpful to confirm and supplement this information with direct observations. This should be done continuously throughout the research process. By employing the ideas from process consultation (Schein, 1969) a more in depth understanding of interpersonal relationships and potential barriers to change may be gained. Observations are done in a detached manner, by sitting in on meetings, or as a participant observer who collects information while working in the organization. The appropriate role of the researcher will depend on the nature of their relationship with the organization.

Once a general understanding of the organization's processes has been gained, a process flow is outlined. Depending on the organization and time available, it may be necessary to conduct only one interview. However, because organizational processes, especially those with a spatial component, are complex, it is helpful to conduct interviews in stages. This allows a preliminary process diagram to be developed from the first set of interviews, with follow up interviews to confirm and fill in missing details. In the second set of interviews, specifics about the activities, tasks, inputs and outputs will be determined. These interviews, along with ongoing observations, will assess details such as the time and material requirements of a task, and a rating of satisfaction with the inputs, outputs and processes. When these are completed the process flow diagram for the organization is finalized with associated data about inputs and outputs.

Phase II - Identify Potential Areas for GIS Application

By using the results of Phase I, specific activities and tasks can be identified as appropriate for GIS use. Coupling this with information about technical skills and data availability, applications can be developed that use GIS to improve upon existing processes. Although this is a subjective process, the importance of this phase should not be underestimated. Political and social factors can have a strong influence on the effectiveness of GIS. For an organization that is just beginning to apply GIS it is important to start with appropriate and helpful applications with a high probability of

success. If initial attempts fail, it can effect individuals' attitudes toward the technology and may inhibit future applications.

Phase III - Process Analysis with GIS

The third phase of the methodology is conducted after GIS has been introduced. The product of this phase is a new flow diagram for the organization's processes with GIS. The inquiry should begin by determining where and how GIS has been applied since the initial analysis. Then, the details about the activities, tasks, task flow, inputs and outputs are gathered. The methods of first-hand observations, interviews and surveys are the same as in Phase I, but are likely to take less time depending on the time lag between phases. The presumption here is that some impacts and changes will occur with the introduction of GIS. If this is not the case, it will be determined in Phase IV. If there are changes, they are evaluated in Phase V.

Phase IV - Identification of Changes in Process

The goal of this final descriptive phase is to identify if and how activities have changed due to the introduction of GIS. Is the process the same? Are there new activities or tasks? Have tasks been eliminated? What are the changes in inputs and outputs? Has satisfaction with results changed? These questions are answered by comparing the process flow diagrams and survey results from Phases I and III. Three types of changes may occur: changes in the process itself; changes in inputs; changes in outputs.

An extreme case of change would be if GIS is used to re-engineer a process. For example, if a city is implementing GIS and new data standards and requirements are put in place, than this is likely to effect many internal and inter-organizational processes. However, GIS is not necessarily the factor causing change, the new policies may be the driving factor. Therefore, care must be taken in interviews and observations to separate changes due to GIS from changes in policy where possible.

Phase V - Assessment of Impacts

Once changes have been identified, the organization can begin to assess them. Were they positive, negative or neutral? This assessment should be made in the context of organizational goals. Examples of goals that might be considered include streamlining a process, saving time or consumable resources, expanding analysis capabilities, facilitating information sharing and improving customer satisfaction. By considering goals it may be possible to evaluate the effectiveness of GIS without placing a quantitative measure on its use. However, there may be opportunities for quantification depending on the level of detail in the data collected about the processes. Directly quantifiable changes include items such as time requirements or paper and ink

consumption. Secondary changes are also important to evaluate. If physical processes are effected due to information gained with GIS, there could be changes in service delivery costs. For example, analysis with GIS may result in more efficient truck routing or service scheduling.

Phase VI - Prescriptive Analysis

The final phase of this methodology uses the knowledge gained about the organizational processes with GIS to guide the future use of the technology. The intent is to take what has been learned to create mechanisms for bringing about more positive changes such as training or new policies. This phase represents a real value of the development and application of a systematic methodology. The understanding gained in the descriptive and assessment phases is interesting, but is only useful if used to improve upon the status quo.

Conclusions

The main contribution of this work thus far is the development of a formal methodology for evaluating the impact of GIS on an organization. The process-based approach presented identifies changes in activities with the introduction of GIS. The focus of the analysis is on the organization rather than on the technology. This ensures that important social factors are not lost in an attempt to place a value on the technology. The intent of this methodology is to provide organizations with a mechanism for benchmarking their use of GIS. This can guide GIS use internally and may be used by peer organizations to compare experiences or estimate potential. As the methodology is applied over time to a variety of organizations, more generalizable information may be found. This can then be used to guide the development of measures of performance for GIS in other industries and endeavors.

References:

Brimson, James, 1991, *Activity Accounting: An Activity Based Costing Approach*, John Wiley & Sons, NY.

Budic', Zorica D., 1994, Effectiveness of Geographic Information Systems in Local Planning, *Journal of the American Planning Association*, Vol. 60, No. 2, 244-263.

Campbell, Heather, 1996, A Social Interactionist Perspective of Computer Implementation, *Journal of the American Planning Association*, Vol. 62, No. 1, 99-107.

Campbell, Heather and Masser, Ian, 1995, *GIS and Organizations: How effective are GIS in Practice?*, Taylor & Francis, London.

Campbell, Heather and Masser, Ian, 1995, Chapter 19 in *The Added Value of Geographic Information System in Public and Environmental Health*, Ed. de Lepper, Scholten and Stein, Kluwer Academic Press, Dordrecht, Netherlands.

Cooper, Robin, Kaplan, Robert, Maisel, Morrissey and Oehem, 1992, *Implementing Activity Based Cost Management: Moving from Analysis to Action*, Institute of Management Accountants, Montvale, NJ.

Coyne, R., McLaughlin, S., Newton, S., 1996, Information technology and praxis: a survey of computers in design practice, *Environment and Planning B: Planning and Design*, Vol. 23, 515-551.

Danziger, J and Kraemer, K., 1986, *People and computers: the impacts of computing on end users in organizations*, Columbia University Press, New York, N.Y.

Innes, Judith E. and David M. Simpson, 1993, Implementing GIS for Planning: Lessons from the History of Technological Innovation, *Journal of the American Planning Association*, Vol. 59., No. 2, 230-236.

Kraemer, Kenneth L., Danziger, James N., Dunkle, D., King, J., 1993, The Usefulness of Computer Based Information to Public Managers, *MIS Quarterly*, June, 129-148.

Kraemer, Kenneth L., King, John Leslie, 1977, *Computers and Local Government, Volume 1, A Managers Guide*, Praeger Publishers, New York.

Kraemer, Kenneth L., King, John Leslie, 1977, *Computers and Local Government, Volume 2, A Review of the Research*, Praeger Publishers, New York.

Masser, Ian, Campbell, H. and Craglia M., 1996, *GIS diffusion: the adoption and use of geographical information systems in local government in Europe*, Taylor & Francis, London.

Mooney, John G., Gurbaxani, Vijay, Kraemer, Kenneth L., 1996, A Process Oriented Framework for Assessing the Business Value of Information Technology, *Data Base*, Vol. 27, No. 2, 68-81.

Nedovic-Budic, Zorica, and Godschalk, David, 1996, Human Factors of Geographic Information Systems: A Local Government Case Study, *Public Administration Review*, Vol. 56, No. 6, 554-567.

Norris, Donald F., Kraemer, Kenneth L., 1996, Human Factors of Geographic Information Systems: A Local Government Case Study, *Public Administration Review*, Vol. 56, No. 6, 568-576.

Norris, Donald F., 1989, *Microcomputers and local government, 3rd edition*, International City Management Assoc., Washington, D.C.

Schein, Edgar, 1969, *Process Consultation: Its Role in Organization Development*, Addison-Wesley, Reading, Massachusetts.

3

GIS USE IN PUBLIC AGENCIES IN COLORADO

This chapter will summarize the results of 24 interviews with public officials in the State of Colorado who use, or are beginning to use, GIS in their agency. The researchers did undertake a statistical sample to select the survey participants because they did not have access to a complete list of GIS users in the State. Instead, an attempt was made to contact as many public sector users as possible on the Front Range of Colorado, and in some Western Counties. In order to obtain a more thorough understanding of each agency's experiences with GIS, face to face interviews were conducted rather than mailing out surveys. Therefore, no claims can be made about the statistical significance of any of these results. However, there was a great deal of similarity in the experiences of users. By comparing these agencies to Stapleton Development Corporation recommendations can be made about institutional changes to support GIS, and a qualitative list of benefits and costs can be presented to estimate the impact that GIS could have at SDC.

Summary of Interviews

The history of GIS acquisition and implementation varied greatly from agency to agency. While some organizations had been working with digital information for ten to twenty years, others were just beginning to explore the use of GIS. The majority of people interviewed, however, knew of the existence of a champion in starting the GIS effort. This person played the role of applying for or lobbying for funding to acquire the necessary hardware, software and data for implementing GIS. They were also frequently the main GIS user, or the person who hired a GIS analyst. All but three of the organizations interviewed had at least one specific person who worked with GIS as part of their regular job requirements. Those that did not were still in the infancy of GIS use, and were only using the desktop mapping capabilities of GIS.

One of the questions asked in the survey was whether or not GIS had changed the way that tasks were done. About two-thirds of the respondents said that it had, but few were able to specify how tasks had changed. Rather, most indicated that GIS had increased the speed of task completion, thus enabling more tasks to be completed. An assessor's office and a wastewater agency provided two specific examples of how tasks were changed. The assessor's office stated that the subdivision review process was enhanced by the ability to overlay and compare information about slopes and

floodplains with parcel and road information. The wastewater division indicated that their ability to calculate impervious surface area was enhanced, which is the basis for their fee collection. This could now be done directly with GIS.

All of the organizations that were using GIS to any extent at all felt that it has added value to the work completed. The values sited most often were related to GIS output capabilities and output quality. Other values that were mentioned included the ability to communicate ideas, the ability to share and access data, the speed of information access, and the ability to perform spatial analyses. The only organization that noted a financially measurable value due specifically to GIS was the Wastewater Management Division in the City and County of Denver. This was due to their ability to calculate impervious surfaces, as mentioned earlier. The increased accuracy of their calculations led to an increase in revenues from wastewater fee collections. As a result rates were not increased.

One specific change that participants in the interviews were asked about was whether or not GIS effected their ability to communicate with others. The majority of respondents felt that it had improved their ability to communicate internally, as well as with the public. However, about twenty percent of the participants did not recognize a change in communications as a value of GIS. One participant did note that GIS could be a detriment in some cases because the communications became focused on the technical details of the GIS rather than on the issue at hand.

When asked what the main benefits of GIS were for the organization, the most frequent responses were more efficient access to data and information and the ability to present information graphically. Other sited benefits were: the ability to do research; the availability of spatial analysis and modeling capabilities; increased speed in producing graphical outputs; ability to produce outputs such as overlays that were not possible before GIS acquisition; improved data sharing and data access; public relations and service to the public; greater accuracy; and improved data protection and storage. One respondent noted that using GIS has required that organization to look more closely at their data in terms of completeness, timeliness and accuracy. That is, GIS can raise the standards for data use by public agencies. Finally, another participant indicated that there was an opportunity cost for not using GIS. Without it agencies would fall behind a presumed standard of professionalism for performing their work and serving their public.

Of course, with these benefits, as qualitative as they may be, are costs. When asked about the most important problems associated with the acquisition and implementation of GIS, the most frequent response was the lack of resources to achieve all of the goals desired. These resources are needed for hardware and software, to provide all agency staff with access to GIS, for time to train and become accustomed to GIS, for time to maintain data, and for funding and time to develop data to support desired analyses. Lack of data quality in terms of accuracy and timeliness was the second most sited

problem. Close behind that was the lack of understanding about the capabilities of GIS both within the organization, and by politicians whose support for GIS is necessary. Other problems are: under-utilization of GIS; data control issues with other agencies; the rapidity of change in the technology; the fact that expectations of GIS exceed the ability of the organization; the long start up time to become proficient in using GIS; and the long time lag between GIS acquisition and the realization of benefits.

Overall, respondents were cautiously enthusiastic about GIS. It is important to note, however, that those interviewed had a vested interest in the success of GIS since it was instrumental for their employment. There were references to GIS efforts that had started and failed. The supposed reasons for these failed efforts included lack of political support, and the long period of time to realize benefits.

Comparison to Stapleton Development Corporation

The experiences of those interviewed do not vary greatly from what has been observed of SDC's use of GIS. The most important differences between SDC and the organizations interviewed were SDC's lack of a GIS champion, and the lack of a staff member who has GIS as part of their job description. Clearly, if there is nobody who believes in and understands GIS enough to begin using it in their work, it will not be applied. In order for GIS and DSP to survive at SDC, it is imperative that a staff person be assigned to integrate GIS into the organization. This person should have a role in the regular business activities of SDC, and have sufficient GIS experience that includes data development capabilities. It is important that this person not be solely focused on the technical aspects of GIS because they will have difficulty integrating with the rest of the staff. Rather, it would be preferable if this person were part of either the Development or Open Space and Environment Departments since these are the units for which spatial analysis capabilities are most closely linked. It will be necessary for this person to take on the task of GIS in an enthusiastic but realistic manner. If this person is not able to develop into the GIS champion, it is likely that DSP and GIS will not be applied at SDC.

Another barrier for SDC in achieving the full potential of GIS for planning, managing and delivering services to the Stapleton site is the lack of GIS in the City and County of Denver. Denver does not have a system wide GIS, and GIS use is minimal and sporadic in most City agencies. However, there is a movement to expand GIS within the City, and the experiences of Denver's Wastewater Management Division provide support for the potential of GIS in service delivery. If SDC can successfully demonstrate the use of Denver Smart Places at Stapleton, even for small-scale applications, it could strengthen the City's effort to grow GIS.

Even the limited application of DSP thus far has produced a couple of benefits. The most notable of these is the ability to create graphical outputs that were not possible to

do in-house before. Related to this is the improved quality of these outputs. Another factor that is recognized by the staff at SDC is the opportunity cost for not having GIS capabilities in house. In addition to the public, many of the constituents with whom SDC works are experienced professionals. These stakeholders expect an organization responsible for developing a large area of land over the next few decades to utilize state of the art technology. For this reason, the mere existence of DSP at SDC provides a good public relations tool, whether or not it is fully applied. These are some of the same benefits noticed by the organizations interviewed.

If SDC begins to apply DSP/GIS to a greater extent, they could expect to achieve some of the benefits found by other public agencies using GIS. These include:

- More efficient access to data.
- Ability to view graphical information in new and creative ways, including overlaying thematic maps to demonstrate spatial relationships and patterns.
- Improved coordination of data and information sharing.
- Data and information storage and protection.
- Enhanced analysis and modeling.
- Increased speed in completing some tasks.
- Enhanced communication with the public, consultants, and constituents.
- Fewer steps required to complete some operations such as calculating spatial areas, buffer zones, etc.

Some of the problems encountered by organizations interviewed have also been noticed at SDC. This includes a lack of use or under-use of the system. This is due to a lack of understanding of the capabilities of GIS and DSP by staff because GIS has not been a part of their formal professional training or practices. In order to overcome this, a shift in thinking must occur in the planning and design professions to appreciate the potential and understand the limitations of computer tools such as GIS. This will only happen as new generations of professionals are educated with GIS and share their experiences with their colleagues.

As demonstrated by public agencies that utilize GIS, even with regular use its application will not be free of problems. First, as noted by those interviewed, there is a general lack of understanding of the potential of computers by local politicians. This could make it difficult for SDC to obtain funding to obtain the staff, hardware and software to spread the use of DSP throughout the organization. Political issues may also arise in working with other agencies in the City and County of Denver, and in the

other cities and counties near the site. Data sharing and coordination is an important step in helping GIS achieve its full potential, especially if planning and management is to be done on a regional scale. However, each political jurisdiction has their own set of goals and priorities for developing and using GIS data, and these are often incompatible with those of other jurisdictions. For example, the level of precision and accuracy required by a city's engineers will be much higher than that of a land use planner. Issues of measurement, scale and timeliness will arise as different agencies attempt to coordinate their data efforts. Stapleton is likely to encounter these same issues.

In addition to data coordination, SDC will have to resolve issues of data and hardware maintenance, data accuracy, funding for data and system development, and additional training requirements as hardware and software technology progress. There will also be the issue of unfulfilled expectations as some individuals expect more from the system than the organization can produce due to limitations in data, technology or funding. Finally, in order for DSP to be applied in a manner that benefits SDC, the SDC staff must be persistent and patient. Many of the public sector professionals interviewed noted that there is a frustrating and long start up time required, and an even longer than desired time before tangible benefits are realized. That is why a champion is so critical to the successful implementation of GIS. Without an individual who can endure through the difficulties, the true value of GIS will never be achieved.

To summarize, SDC can expect their experiences to be similar to the other public agencies interviewed. There is a general agreement by those agencies using GIS, that it is an asset to their organization. It is important to distinguish between applications such as planning, and more technical uses such as service delivery. Each type of application will have different accuracy and analysis needs. It is important to the success of GIS implementation that these differences are stated clearly so that people are not disappointed by the results. By starting with smaller, less technical applications, success and confidence can be built. Then, more precise and sophisticated uses may be applied as users become more proficient and comfortable with the technology and its capabilities.

The organizations that participated in the survey were:

- City and County of Denver - Planning Office
- City and County of Denver - Wastewater Management Division
- Boulder County - Land Use Department
- Denver Water - Planning and Natural Resources Division
- Denver Water - Information Systems Division

- Arapahoe County Assessor's Office
- Jefferson County - GIS Department
- Garfield County
- Larimer County
- Routt County
- Adams County
- State of Colorado - Department of Local Affairs
- State of Colorado - Department of Natural Resources
- City of Englewood
- City of Boulder - Open Space and Real Estate
- City of Boulder - Wastewater Department
- City of Boulder - Planning Department
- City of Boulder - Public Works
- City of Longmont
- City of Fort Collins
- City of Greeley
- City of Loveland
- City of Aspen